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**EFFECTS OF DEVELOPMENT AND NOVEL CONSTRUCTION
TECHNIQUES ON YIELD OF A WATER WELL DRILLED IN
CRYSTALLINE ROCK, WESTMINSTER, MARYLAND**

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ABSTRACT

The crystalline-rock aquifers underlying most of north-central Maryland are characterized by a strongly skewed well-yield distribution having a preponderance of low values. Municipal and other non-domestic users commonly require higher well yields. Selecting the optimum well site on the basis of topographic or geologic factors improves the odds of obtaining a higher well yield, but often site selection is very constrained; thus the problem becomes how to maximize the well yield attainable at a given site.



Wells completed in the fractured-rock terrane of Maryland are commonly developed simply by blowing compressed air through the drill bit after completion of the well, which may not provide sufficient development. To obtain quantitative data on the efficacy of several methods of well construction and development, a test well was drilled in the crystalline rock in Westminster, Carroll County, Maryland. The methods tested include brushing and surging, hydraulic fracturing, increasing well diameter from 6 to 15 inches, and drilling inclined collectors (rakers).

A 3-inch corehole was drilled initially to a depth of 234.5 feet in order to provide hydrogeologic information for the well site, which is underlain by marble-bearing phyllite of the Sams Creek Formation. The corehole was overdrilled at a diameter of 6 inches to a depth of 254 feet, was brushed and surged, and hydraulically fractured. The hole was again overdrilled, at a diameter of 15 inches to a depth of 241 feet, and was brushed and surged. Two 3-inch coreholes were drilled toward the 15-inch well at inclinations of 45° and 37° for the purpose of improving hydraulic connections between fractures.

Six step-drawdown pumping tests were conducted after various stages of construction and development of the test well using pumping rates ranging from 24.3 to 285 gallons per minute. The results of these tests indicate significant improvements in well yield due to the increase in well diameter from 6 to 15 inches, but no significant changes due to brushing and surging, hydraulic fracturing, or construction of the two inclined collectors. The analytical methods of Jacob (1947), Rorabaugh (1953), and Labadie and Helweg (1975) could not be applied to the step-drawdown test results, apparently because of the heterogeneous nature of the hydrologic system under consideration, in which solutional voids strongly influenced ground-water flow in the vicinity of the well. Nevertheless, plots of well characteristics do show semiquantitatively the effects of the yield improvement efforts.

The 6-inch well was pumped at an average rate of 168 gallons per minute for 12 hours. The specific capacity at the end of this period was 8.7 gallons per minute per foot. A second constant-rate pumping test was conducted after the well was enlarged to 15 inches in diameter, brushed and surged, and two rakers drilled. The initial pumping rate of 248 gallons per minute could not be maintained, and after 1,000 minutes dropped off to about 160 gallons per minute. Specific capacity after 12 hours was 6.9 gallons per minute per foot, and after 24 hours was 5.2 gallons per minute per foot. Water-level behavior during this test was characteristic of linear flow. This change in behavior from the test at the 6-inch diameter suggests that the larger diameter well with two rakers, which could produce water more efficiently, very quickly passed through a radial flow regime and into a regime in which a linear geometry (of voids and/or fracture zones) controlled ground-water flow to the well.

A water sample was collected during the second constant-rate pumping test. The water was undersaturated with respect to all common minerals except quartz and contained relatively high concentrations of chloride and nitrate (the likely sources being nearby road salting and agricultural fertilizing)—perhaps reflecting rapid ground-water circulation through shallow weathered rock and cavernous zones.